Pavement Standards Team (PST)

Pavement Advisory

Number: PSTPA-02

Effective Date: IMMEDIATE

Approval Date: September 6, 2005

Title: Designing Quieter Pavements

This advisory applies only to pavements, not bridges or structure approach slabs which are under the purview of Structures in the Division of Engineering Services.

ISSUE

The issue of quieter pavements has received increasing attention nationwide over the past several years. Traffic noise has become a growing public concern.

The Federal Highway Administration issued a letter on January 19, 2005 to all State DOTs (see attachment) reiterating "The FHWA policy restricts making adjustments for pavement type in the prediction of highway traffic noise levels and using specific pavement types or surface textures as noise abatement measures." This means that FHWA will not participate in the costs for pavement work done solely for the purposes of reducing noise. FHWA stresses the need to not compromise safety and durability for noise reduction in meeting requirements found in NEPA and 23 CFR 772 for abating and maintaining noise. In their letter FHWA also notes their support in researching the issue and ultimately left open the possibility of modifying their policy based on this research. California has been investigating quieter pavement strategies for the last seven years and has developed several test sections. Arizona has also been testing thin overlays as a quiet pavement strategy for a number of years. Arizona has embarked on a program to overlay its urban freeways with open graded asphalt to reduce noise. Because of differences between Arizona's and California's pavements, California has not adopted Arizona's program. See p. 4 "Difference Between Arizona's and California's Pavements" of this advisory for further information. Several other state DOTs are working on developing additional research. Because one of the issues that FHWA wants addressed is how long pavement will maintain its noise benefits, it will be several more years before this research is fully completed.

In the mean time, with increasing attention, there has been a lot of information and misinformation distributed regarding this issue. Since the Department strives to provide the best product possible to the public, this advisory is being issued to provide designers with the most

current information available and provide interim recommendations on how to design pavements that are safe, long lasting, and quiet.

For reference, a 3dBA change in noise levels is barely perceptible to an average healthy ear. Caltrans constructs sound walls (in accordance with Federal requirements) after a reasonable and feasible analysis determines that a 'readably perceptible' decrease of 5 dBA or more can be achieved.

CURRENT INFORMATION

Recent developments in testing now allow us to measure pavement noise separate from other noise factors. Based on research done to date and other experiences and comparisons here is what we know today:

1. Of the primary noise sources emanating from a vehicle, the noise generated from the interaction between the tire and pavement is the only variable transportation departments have some immediate control over. For passenger cars operating at freeway speeds, tire/pavement noise accounts for 75-90% of the overall wayside noise levels. The acoustics for heavy trucks is much more complex and the Department is examining this topic. Caltrans has a number of on-going studies that are examining various aspects of traffic related noise.

2. California's longitudinally tined concrete pavements are already 4 to 7 dB quieter than other states (including Arizona) that use transverse tining surface texture.

3. California's standard open graded asphalt pavements (conventional and rubberized) have noise readings that compare favorably with other "quiet pavements" developed in other states and in Europe. Caltrans will be testing some additional designs developed in other states and in Europe over the next several years.

4. Mixes with increased void content (like open graded asphalt) and smaller rock size seem to provide better noise performance.

5. While dense graded asphalt is typically quieter than concrete pavement, it is not necessarily always the case. Studies in California and the Midwest seem to show that well built concrete pavements which avoid transverse tining and give proper attention to surface texture can be statistically equivalent to dense graded asphalt mixes.

6. Caltrans has also seen some success in reducing noise on concrete pavements by grinding, but this really depends on the initial condition of the concrete. Significant

decreases in tire/pavement noise have been achieved when transversely textured concrete pavement is ground longitudinally. One interesting example of a successful grind on a recently built concrete pavement is on Route 85 in Santa Clara County, where a "whisper grind" reduced noise to the satisfaction of neighboring residents. Even though tests showed an overall 2 dBA reduction in noise, the grinding on Route 85 produced more uniform noise levels and showed a greater reduction in frequencies around 1600 Hz than at other ranges. It is possible but not proven that grinding may have changed the noise at the frequencies that were the most annoying to neighboring residents and created a surface with a more uniform sound.

7. Quality matters. Although additional data are being collected, there does appear to be a correlation between the quality of workmanship and noise performance. For example, we are seeing higher than average noise measurements for pavements that are also rougher than average. Poorly constructed pavement joints generate louder joint slap noise, which in turn increases overall noise levels. Also faulting on old concrete pavements increases noise. Caltrans has instituted the following improvements to its pavement design & practices, which will improve their noise performance in the future:

    a. Enhanced smoothness specifications for asphalt and concrete pavements (see attached letter from Randall Iwasaki dated March 25, 2005)

    b. Use of dowel bars in concrete pavements which reduces faulting by up to 90% and can double the pavement service life for faulting.

    c. Increased use of open graded asphalt mixes on asphalt pavements.

8. Caltrans has not found any significant difference in noise performance between California's conventional and rubberized open graded asphalt pavements. Of what has been tested to date, open graded mixes are typically 3 – 5 dBA lower than conventional dense graded asphalt pavements. Caltrans has yet to test gap or dense graded rubberized asphalt pavements. Further investigation is needed and underway to sort out how material properties like aggregate size, surface texture, and void content effect noise performance. Although there is no apparent noise benefit from using rubber, there are other benefits, such as increased longevity.

9. Generally, the acoustic variation of a California pavement on a single project is a maximum of 1.5 dBA. Recently, we have run across a project where the same type of rubberized asphalt open graded was placed in two directions of an urban freeway using the same contractor but where there was a 3.5 dBA difference in noise measurements between directions. We are currently trying to ascertain what is causing this large variation.

10. At this point it is too early to tell how pavements will perform over time. Limited studies to date indicate that the noise measurement on their open graded asphalt overlays will increase by about 1 dBA per every three years. California is currently in the sixth year of testing the long term noise performance of open graded overlays. Additional testing is planned over the next three years to collect enough data to identify performance trends over the service life of the surface treatment.

11. Although California pavements are typically quieter than other states, we have identified or are looking at strategies, textures, and mixes which could potentially be even quieter. Over the next several years, as resources allow, we hope through our own efforts or in collaboration with other states, to test these alternate designs.

DIFFERENCES BETWEEN ARIZONA'S AND CALIFORNIA'S PAVEMENTS

Because there has been an increased awareness and discussion of Arizona's program, it should be noted that there are differences between Arizona's and California's pavement. The purpose of the section is to provide the reader with information on how California's concrete pavements differ from Arizona's and why the Department is not pursuing the same program of thin overlays that Arizona is doing.

1. Noise measurements on California's concrete pavements are 4 to 7 dBA quieter than equivalent Arizona concrete pavements while the noise measurements between California's and Arizona's open graded asphalt pavements are virtually identical. The differences between the concrete pavements of the two states as measured was due primarily to the uniform and randomly transverse tined textures Arizona chose to use; they have recently switched in 2002 to longitudinal tining to lower the tire/pavement noise levels. Therefore Caltrans will not see as dramatic a noise reduction from this approach.

2. California's concrete pavements are older (typically 30 to 50 years old) than Arizona's (typically less than 15 years old) and as a result have more distress. Because of this, placing thin overlays on pavements with higher distresses will result in faster deterioration of the overlay and a more rapid loss of acoustic benefits.

3. California has higher levels of traffic volumes/congestion than Arizona and more stringent lane closure requirements. This does make it more difficult and in some cases impractical to place and maintain thin open graded overlays to achieve high quality acoustic benefits on a number of California freeways. Open graded asphalt (particularly rubberized asphalt) needs to be placed in warmer temperatures which cannot always be achieved when night work is the only option. Arizona has already experienced some

early failures of their open graded overlays because they were placed in too cold of ambient temperatures.

4. California has 16,000 lane miles of urban freeway compared to Arizona's 1500 lane miles. The current cost for Arizona's program is $100 million and climbing. Extrapolating from Arizona's experience, a similar program in California would cost in excess of $1 billion not accounting for any repair work to existing pavements.

RECOMMENDED ACTIONS

- **New Construction**

In designing new pavement, both Caltrans and FHWA agree that the primary consideration in the design should be safety (including for maintenance/construction workers) and durability (longevity). Therefore pavement selection, such as whether to use an asphalt or concrete surface should be based on these factors. Life cycle cost analysis should be used to determine whether a concrete or asphalt surface is the most cost effective over time.

Although, safety and durability should be the controlling criteria, this does not mean that pavements cannot also be designed to be quieter as well. The following steps are recommended to improve noise performance of concrete and asphalt pavements.

1. Use the most current versions of standard plans and specifications. These include changes made to improve pavement performance.
2. Use the new pilot specifications for smoothness (see attached letter from Randall Iwasaki dated March 25, 2005). Smoother pavements not only improve longevity of pavements, but also help reduce noise.
3. Enhanced inspection and stricter enforcement of current specifications. Poor quality construction leads to rougher, noisier, less durable pavement. Further improvements to specifications requested by Districts will be considered on a case-by-case basis (see nSSP policy).

Caltrans is also evaluating several new strategies and designs that show some promise for reducing noise while maintaining or improving safety and durability and is interested in creating some test sections for evaluation. These include reduced joint widths for concrete pavement, continuous reinforced concrete pavement, alternate surface textures, and alternate asphalt mix designs. If interested in building a test section, please contact Linus Motumah, Office of Pavement Design, at (916) 227-5851.

Additionally, Caltrans would like to construct pilot projects that improve smoothness. To request using the pilot smoothness specification or make modifications to existing specifications, please contact Tom Pyle at (916) 227-72871 for concrete pavement, and Terrie Bressette at (916) 227-7303 for asphalt projects. All of the pilot projects will require noise measurements and performance monitoring for several years.

- **Rehabilitation, Preservation, and Previously Built Pavements**

Concrete Pavement

The most promising strategies for reducing noise on older concrete pavements are either grinding or an open graded asphalt overlay. Open graded asphalt pavement is typically quieter than concrete when initially built, but pavement noise will increase at a faster rate than concrete. Open graded asphalt will also need to be periodically removed and replaced requiring lane closures and exposure of maintenance/construction personnel. Grinding has performed longer than open graded asphalt but can only be done so many times (typically 2 to 3) before the concrete pavement becomes too thin and loses integrity.

When designing a surface treatment for a previously built concrete pavement, the following steps are recommended:

1. Failed sections of concrete pavement (e.g. slab replacements) should be replaced prior to performing any surface treatment. Grinding will not improve these sections and experience has shown that asphalt overlays will fail prematurely (some projects have failed within 2 years).
2. Grinding should be considered first. Grinding has been successfully used in the past to address noise complaints from neighboring residents and it provides a smooth long lasting surface. Other things to keep in mind are:
    a. Grinding reduces faulting and the resulting noise "slap" at the joints.
    b. Grinding can be limited to just a few lanes but open graded asphalt has to be applied throughout.
    c. Even if an open graded surface is applied, the existing concrete will need to be ground to eliminate faulting and other anomalies that will reduce the service life of the overlay.

    A grinding specification should be used that requires the contractor to grind to a specific smoothness and to grind the entire surface rather than one that has a maximum depth of grind. This is necessary to avoid leaving any faulting or rough areas in the pavement.
3. Before deciding to place an open graded asphalt overlay, a life cycle cost analysis should be performed to verify if it is cost effective. Consideration should also be given as to whether it can be maintained or replaced in the future given the anticipated traffic and

lane closure constraints. Repair of failed areas and grinding should be completed prior to placing the overlay. Rubberized open graded asphalt is preferred because it resists reflective cracking from the concrete joints for a longer time than conventional open graded.

Asphalt Pavement

Open graded overlays are recommended for asphalt pavements regardless of whether they are used to reduce noise or not. Open graded surface courses, provide a wearing surface that can protect the dense graded layers, allow rainfall to drain into the open graded layer and off the pavement, and improve visibility in wet weather conditions. Caltrans open graded asphalt pavements are not suitable in all environments such as in freeze/thaw environments. When overlaying asphalt pavement in urban or other noise sensitive areas, the use of an open graded asphalt surface course is recommended. Gap graded rubberized asphalt pavement can also be used, but its noise benefits have not yet been determined.

UPCOMING ACTIVITIES

Caltrans will continue to pursue research on this subject and update guidance as new information becomes available. A web site for quieter pavements will be established by November 15, 2005 to provide the latest information to those designing pavements on state highways. The web site will be accessible from the Pavement web site at http://www.dot.ca.gov/hq/oppd/pavement/index.htm. For further information on pavement issues related to noise, please contact Linus Motumah at (916) 227-5851 or William K. Farnbach at (916) 227-5845 of the Office of Pavement Design in the Division of Design. For additional information on noise measuring issues, contact Bruce Rymer at (916) 653-6073.

DURATION

This advisory will expire on July 1, 2008, unless updated before July 1, 2008.

APPROVED

September 7, 2005

TOM HOOVER
Project Manager
Pavement Standards Program

Date

State of California
DEPARTMENT OF TRANSPORTATION

Business, Transportation and Housing Agency

Memorandum

Flex your power!
Be energy efficient!

To: DISTRICT DIRECTORS

Date: March 25, 2005

From: **RANDELL H. IWASAKI**
Chief Deputy Director

Subject: Smoothness Specification Pilot Projects

In support of the California Department of Transportation's goal to improve mobility, a recent effort by the Pavement Standards Team (PST) has led to the introduction of an enhanced smoothness specification that includes an incentive/disincentive clause. The objective of this effort is to provide the traveling public with a smoother-riding pavement by providing contractors with an incentive for constructing smoother pavements. National experience has found that smoothness can improve the performance of pavements by 15 to 40 percent.

The PST is seeking assistance of the districts. The team would like to pilot these specifications on six to ten projects statewide that are scheduled for construction this coming spring/summer. The proposed projects should be a mix of dense-graded asphalt concrete (DGAC) and portland cement concrete (PCC) pavements.

The specification can be used on new and rehabilitated pavements. The projects should be at least five kilometers in length for DGAC pavements and three kilometers for PCC pavements. They can be either divided or undivided highways.

DGAC rehabilitation projects require a minimum overlay thickness of 90 mm. There is no minimum for new construction projects. Avoid widenings and shifting of centerlines.

PCC rehabilitation projects should be a substantial lane replacement or widening at least three kilometers in length. Avoid grinding projects.

It is anticipated the increased total project cost as a result of this specification would be in the one to two percent range. The project's contingency fund and G-12 fund should be able to fund the incentive payment. The Division of Transportation Programming has offered to assist the districts with this funding effort.

Should you have any questions, please contact Peter Vacura, Materials Engineering and Testing Services in the Division of Engineering Services, at (916) 227-5845 or via e-mail.

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